Geophysical Research Abstracts
Vol. 17, EGU2015-14085, 2015
EGU General Assembly 2015

Identification of Ice Nucleation Active Sites on Silicate Dust Particles

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Mineral dusts originating from Earth's crust are known to be important atmospheric ice nuclei. In agreement with earlier studies, feldspar was found as the most active of the tested natural mineral dusts [1-3]. Nevertheless, among those structures K-feldspar showed by far the highest ice nucleation activity. In this study, the reasons for its activity and the difference in the activity of the different feldspars were investigated in closer details. Conclusions are drawn from scanning electron microscopy, X-ray powder diffraction, infrared spectroscopy, and oil-immersion freezing experiments.

We give a potential explanation of the increased ice nucleation activity of K-feldspar. The ice nucleating sites are very much dependent on the alkali ion present by altering the water structure and the feldspar surface. The higher activity of K-feldspar can be attributed to the presence of potassium ions on the surface and surface bilayer. The alkali-ions have different hydration shells and thus an influence on the ice nucleation activity of feldspar. Chaotropic behavior of Calcium and Sodium ions are lowering the ice nucleation potential of the other feldspars, while kosmotropic Potassium has a neutral or even positive effect.

Furthermore we investigated the influence of milling onto the ice nucleation of quartz particles. The ice nucleation activity can be increased by mechanical milling, by introducing more molecular, nucleation active defects to the particle surface. This effect is larger than expected by plane surface increase.

[1] Atkinson et al. The Importance of Feldspar for Ice Nucleation by Mineral Dust in Mixed-Phase Clouds. Nature 2013, 498, 355–358.

[2] Yakobi-Hancock et al.. Feldspar Minerals as Efficient Deposition Ice Nuclei. Atmos. Chem. Phys. 2013, 13, 11175–11185.

[3] Zolles et al. Identification of Ice Nucleation Active Sites on Feldspar Dust Particles. J. Phys. Chem. A 2015 accepted.